

Investor Inattention and the Market Impact of Summary Statistics*

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Abstract

Investors with limited attention have an incentive to focus on summary statistics rather than individual pieces of information. We use this observation to form a test of the impact of limited attention on the aggregate stock market. We examine the market response to a macroeconomic release that is purely a summary statistic, the U.S. Leading Economic Index (LEI). Consistent with the limited attention hypothesis, we show that the LEI announcement has an impact on aggregate stock returns, return volatility, and trading volume. Furthermore, we find evidence that the response to the LEI is higher for stocks which inattentive investors are more likely to trade.

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1 Introduction

For most investors, the costs of processing all relevant information are prohibitively high. As such, these investors can be viewed as having limited attention. Previous studies provide evidence suggesting that investors' limited attention is important for the pricing of individual securities. For example, DellaVigna and Pollet (2007) show that publicly available demographic information is not completely impounded in stock prices. Hirshleifer, Lim, and Teoh (2007) suggest that investors cannot process all the relevant information when many firms release their earnings on the same day, leading to weaker stock price reaction. Huberman and Regev (2001) document an instance where a re-release of news had a large effect on the stock price of a biotech firm. In this paper, we ask whether limited attention also has a systematic impact on the aggregate stock market.

To answer this question, we examine how the release of summary statistics affect the market. Barberis and Shleifer (2003) and Peng and Xiong (2006) highlight that investors with limited attention economize on information processing by grouping stocks into categories. In the same spirit, investors with limited attention may choose to focus on summary statistics instead of attending to every individual piece of information. This implication of limited attention has not, to our knowledge, been tested in the previous literature.

The summary statistic we identify is The Conference Board's U.S. Leading Economic Index (LEI). This index is designed to track business cycle fluctuations and signal turning points in the business cycle. It is economically relevant as it contains information about future cash flows and discount rates, and it has a leading relationship relative to macroeconomic aggregates such as output and employment. Like most macroeconomic announcements, the LEI is released on a pre-determined schedule.

What makes the LEI an important variable in our context is that the components of the composite index are publicly available or can be easily calculated using publicly available data in advance of the announcement. In fact, several of the constituent macroeconomic variables are usually released weeks before the LEI scheduled releases. Furthermore, the methodology used to compile the LEI is also publicly available. These are well-known facts, publicized among other places on The Conference Board's website and Bloomberg.¹ It is therefore possible to calculate the change in the index *before* its release. Based on semi-strong market efficiency, the announcement of the LEI should not impact market returns because

¹See <http://www.conference-board.org/economics/bci/general.cfm> and <http://www.bloomberg.com/markets/ecalendar/index.html>

the information in the component data relevant to fundamentals should already have been incorporated in stock prices.

Our null hypothesis is that there should be no market reaction to the announcements of the index since 1) the LEI is based on previously released data, 2) the components and methodology of the LEI are readily available to the public, and 3) the index is fairly easy to reproduce. However, if limited attention is important for the aggregate stock market, the information in the LEI may be news to investors and as such have a market impact. Further, if this market impact is caused by limited attention, we would expect to find a larger response among stocks in which investors subject to this bias are more likely to trade.

Looking at intraday data over 72 announcement days over the period 1997-2005, we find that the release of the LEI is associated with measures of information arrival such as market returns, return volatility, and trading volume. The market return is positively related to the changes in the LEI: A one standard deviation increase in the LEI on average leads to a 3.5 basis-point increase in the subsequent 5-minute market returns. Aggregate return volatility and trading volume increase by 25% and 7%, respectively, following the announcement. The volatility increase is significant for the 5-minute interval following the announcement, while the volume increase persists for the subsequent 30 minutes.

The absolute level of the return response is fairly low. However, this result is expected given that limited attention should affect markets less if the information is market-wide, as is the case here. Investors have a higher incentive to be attentive to information that is more important for their utility and, as a group, investors therefore focus more on market-wide information. Further, since the release is recurring and perfectly forecastable, one would expect attentive arbitrageurs to eliminate profit opportunities arising from the release up to transaction costs. Therefore, the tests in this paper are stacked against the alternative hypothesis of limited attention. Nevertheless, when we use quote and volume data from the SPDR (Spider) exchange-traded fund,² we find that a simple trading strategy, which goes long (short) the market prior to positive (negative) LEI announcements, delivers on average positive daily volume-weighted profits.

To examine the robustness of the results we test another hypothesis. If the market impact of the LEI announcements is caused by limited attention of a subset of investors, we would expect to find a larger impact on stocks which investors subject to this bias are more likely to trade. We test this conjecture by looking at the cross-sectional return response to the LEI release. Barber and Odean (2006) show that individual investors focus on “attention-

²The Spider is an exchange-traded fund (ETF) designed to track the S&P500 Index.

grabbing stocks”, such as stocks that are featured in the media and stocks with high volume. Large capitalization stocks tend to have higher volume and are more likely to be covered by the media. Similarly, Lakonishok, Shleifer, and Vishny (1994) argue that value strategies produce superior returns because “naive” investors drive up the prices of “glamour” stocks compared with “value” stocks. We would thus expect that inattention-prone investors are more likely to trade large capitalization stocks as well as stocks with low book-to-market ratios, which should therefore respond more strongly to the release of the LEI. We construct intraday returns for the 25 Fama-French portfolios on the announcement days and show that, consistent with the limited attention effect, the returns of large capitalization stocks respond more to the LEI announcements, compared to small capitalization stocks. The estimated announcement response is higher for low book-to-market stocks than for high book-to-market stocks, again consistent with the limited attention hypothesis, although this difference in response is not statistically significant.

The impact of investors with limited attention on the valuation of financial assets is important because its existence and causes have implications for the efficiency of financial markets. This paper is in that sense related to the large body of literature on market efficiency and more specifically to studies that evaluate the impact of news about fundamentals on asset prices.³ Our study contributes to the literature that relates limited attention to market efficiency along the following dimensions. First, our test is on the aggregate market whereas much of the previous evidence of limited attention concerns company specific news events: for example, Huberman and Regev (2001) and Meschke (2004) who finds that stock prices and trading volume react to CNBC broadcasts of interviews with the relevant company’s CEO. Second, since the LEI announcement is recurring monthly at a known time, agents have the opportunity to learn about the nature of the announcement over time. We do not find evidence that the announcement effect is weaker in the latter part of the sample. Third, the results are unlikely to be explained by risk. As an example, Liu, Whited and Zhang (2007) propose a rational risk based explanation for the earnings-announcement drift of Bernard and Thomas (1990) and Sloan (1996). However, our experiment has its drawbacks: namely that the magnitude of the announcement response and the sample size are relatively small. In summary, the evidence presented in this paper suggests that investors’ limited attention can give rise to violations of semi-strong market efficiency at the aggregate

³Examples of such studies include Schwert (1981), Huberman and Schwert (1985), Cutler, Poterba, and Summers (1989), and Mitchell and Mulherin (1994). Fama (1970, 1991) provides summaries of the market efficiency literature.

market level.

The paper proceeds as follows. Section 2 describes the data used in the empirical tests. Section 3 presents the aggregate stock market results, while Section 4 presents the cross-sectional results. We conclude in Section 5.

2 The Data

In this study, we combine three different data sources: macroeconomic news, intraday index prices and individual stock transactions. The LEI release dates and index series were provided by The Conference Board. It is important to note that we use the original release series (subsequent revisions to macroeconomic data resulted in ex-post updates of the index). In our sample (1/1997 - 8/2005), the index is always reported at 10:00am.⁴

The market returns data are constructed using S&P500 futures prices, while the cross-sectional analysis uses individual stock transactions data from the NYES Trades and Quotes (TAQ) database. The futures data were purchased from Price-Data.com and includes five-minute interval data on open, high, low, and close prices for each of the futures contracts traded between 1997 and 2005. For each date, we determined which of the multiple contracts available are “on-the-run” and constructed the intraday return series for each day using prices from that day’s on-the-run contract. Since aggregate intraday volume data is not readily available, we constructed them by gathering tick-by-tick data from TAQ for all firms that were in the S&P500 index on a given day. We added transactions across all firms for each five-minute interval to arrive at the market volume for that time period.

We use data from the Census Bureau, Bureau of Economic Analysis, Federal Reserve Board, National Association of Purchasing Managers, and The Conference Board to screen out all dates on which other macroeconomic announcements were released simultaneously at 10:00am. The specific announcement are New Home Sales, Factory Orders, Construction Spending, Business Inventories, Consumer Confidence Index, NAPM Index, and the Target Federal Funds Rate.⁵ Therefore, out of a total of 104 announcements in our sample (1/1997 - 8/2005), we exclude 30 due to the simultaneous macroeconomic releases and 2 due to

⁴Before 1997, the LEI was reported at 8:30am, which coincides with the reporting time for a number of other macroeconomic releases (Nonfarm Payroll, Housing Starts, PPI, CPI, among others). The move to the 10:00am announcement time reflected in part a desire to make the announcement during market open hours.

⁵These announcements were identified by Andersen et al. (2007) as having a significant impact on S&P500 futures returns.

unavailable futures prices at the time of the announcements.⁶

2.1 The Leading Economic Index

The Composite Index of Leading Economic Indicators (LEI), calculated and published monthly by The Conference Board (TCB), is designed to predict turning points (peaks and troughs) in the business cycle. TCB took over the responsibility to publish and maintain the LEI and the Business Cycle Indicators database from the Bureau of Economic Analysis starting with the December 6, 1995 release.⁷

Leading indicators are series that have an established tendency to decline before recessions and rise before recoveries.⁸ For instance, new orders for machinery and equipment are placed well before investment plans are completed. By design, the LEI should help predict changes in real economic activity. Figure 1 shows that the LEI systematically declines ahead of the recessions dated by the NBER. Filardo (2004) provides evidence that the LEI performs well as a variable to forecast cyclical movements in the economy. McGuckin, Ozyildirim, and Zarnowitz (2007) also report evidence on the significant out-of-sample forecasting ability of the LEI.

After TCB assumed responsibility for the Business Cycle Indicators program, it reviewed and revised the LEI in 1996. Notably, the composition of the LEI was changed: Two components were deleted due to their excessive volatility which led to “false signals” of recessions and a new component was added (Interest Rate Spread). After this major revision (first released December 30, 1996), TCB also started to publish the LEI press release at 10:00am EST to be consistent with its other economic data releases. Previously, the LEI releases were made at 8:30am, following the BEA schedule.

In the current indexing methodology, which changed very little since the 1960s when the U.S. Department of Commerce began publishing composite indexes, the volatility of each component is standardized before the component contributions are averaged together, using equal weights. This adjustment is made so that relatively more volatile series do not exert undue influence on the index (the standardization factors are updated every year in January and are available in the monthly press releases). The average contribution becomes

⁶We present results including *all* announcements days in Section 3.5.

⁷The indicator approach has a long history since the mid-1930s and was developed at the National Bureau of Economic Research (NBER), following the influential work of Wesley C. Mitchell and Arthur F. Burns. It has been a major component of the NBER program on economic growth and fluctuations.

⁸For more details on the indicator approach to measuring and analyzing business cycles, see Burns and Mitchell (1946) and Zarnowitz (1992).

FIGURE 1

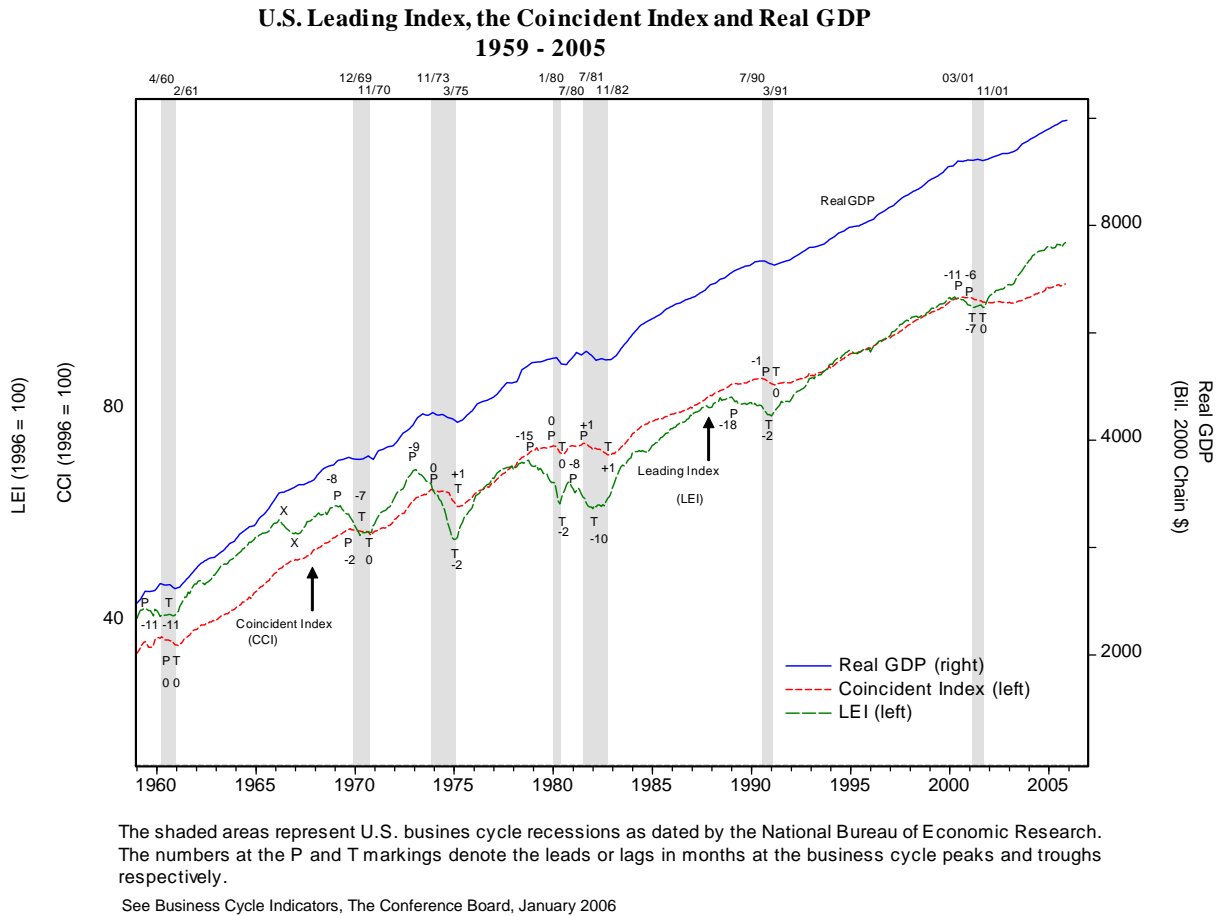


Figure 1: Time series of the Leading Economic Index, the Coincident Index and Real GDP.

the monthly change in the LEI. Using this monthly change, the index level is calculated recursively starting from a value of 100 in January 1959, and it is normalized to have an average value of 100 in 1996.

Seven of the ten indicators used every month in the LEI calculation are available at least 24 hours before each release. The monthly values of the three remaining components which are not available on the publication date are based on estimates by TCB. These components (Manufacturers' New Orders for Consumer Goods and Materials, Manufacturers' New Orders for Nondefense Capital Goods, and the Personal Consumption Expenditure Deflator used to get real Money Supply (M2)) are estimated using a simple AR(2) time series regression.⁹

⁹When the unavailable data become available in the next month, the index is revised.

The Appendix provides more background information and details on why this procedure was selected and how it was implemented by TCB.¹⁰

3 Market Level Results

This section presents the impact of the LEI announcements on aggregate measures of information arrival: stock returns, return volatility, and trading volume. Our null hypothesis is that the LEI announcements have no effect. We focus on intraday market activity for two reasons. First, previous research has shown that the effect of news on aggregate stock market prices are mainly manifested in intraday returns data (Andersen et al. (2003, 2007)). Second, focusing on intraday returns makes our study less sensitive to the presence of other news effects over the same day (including the time from the close the day before) that we may not have captured in our econometric specification.

3.1 General Methodology

A first-order concern when evaluating high-frequency data is the well-known presence of intraday patterns in volatility and volume (Admati and Pfleiderer (1988)). Rather than attempt a parametric model to describe such patterns, for which at present there is no agreed upon model, we investigate return and volatility patterns on LEI announcement days vs. non-announcement days by utilizing a matching study. This allows us to control for both intraday and day-of-the-week effects. Specifically, we match each announcement date with the one week ahead non-announcement date, unless there is another important macro news release on that date, in which case we pick the date following the LEI release.

We evaluate the aggregate return, volatility and volume of announcement days versus non-announcement days over different 5-minute intervals around the time of announcement to investigate any pre- and post-announcement effects. The LEI release is at 10:00 throughout the sample, and we focus on the 9:30 to 10:30 interval.¹¹ Andersen et al. (2007) note that looking at 5-minute futures returns strikes a good balance between capturing fundamental dynamics operating at high-frequencies and minimizing the noise in returns caused by bid-ask bounce and other microstructure issues. The futures contracts on the S&P500 Index are extremely liquid, so empirically neither stale prices nor the bid-ask bounce are

¹⁰The Conference Board (2001) contains extensive details on these procedures.

¹¹In the remainder of the paper, we use the 24:00 time convention when quoting time intervals. Thus, 10:00 is 10:00am.

important issues for our purposes. Further, this approach allows us to compare our results with those obtained in similar studies. For all intervals, we test whether there is a return response at the time of the announcement and whether realized volatility are different on announcement versus non-announcement days.

3.2 Returns

In this section, we investigate the effect of the LEI announcement on S&P500 futures' returns. We first define the normalized change in the LEI index, $\Delta\overline{LEI}_t$, as

$$\Delta\overline{LEI}_t \equiv \frac{\Delta LEI_index_t - E_T[\Delta LEI_index_t]}{\sigma_T(\Delta LEI_index_t)} \quad (1)$$

where $E_T[\cdot]$ and $\sigma_T(\cdot)$ denote the sample mean and standard deviation, respectively. We make this normalization for two reasons: 1) it makes the interpretation of regression coefficients more intuitive, and 2) it makes the results easier to compare to related studies where such normalizations are used.¹² It is usual to subtract the *conditional expectation* of the release and divide by the standard deviation of the imputed shocks. However, since our index is replicable, there are no well-defined “shocks”. Therefore, we simply consider deviations from the sample mean.¹³

We run the regression

$$R_{i,t}^A = \alpha^A + \beta_i^A \Delta\overline{LEI}_t + \varepsilon_{i,t}^A \quad \text{where} \quad t \in [1, 2, \dots, T] \quad (2)$$

where $R_{i,t}^A$ is the intraday interval i 's log return on the announcement day t . Thus, if the interval i is before 10:00, the regressor is the same-day *future* percentage change in the LEI index, whereas if the interval i is after 10:00, the regressor is the same day's already reported LEI change. For comparison, we also run the regression

$$R_{i,t'}^{NA} = \alpha^{NA} + \beta_i^{NA} \Delta\overline{LEI}_t + \varepsilon_{i,t'}^{NA} \quad \text{where} \quad t' \in [1, 2, \dots, T] \quad (3)$$

where the superscript NA refers to the non-announcement day t' , which corresponds to the matched announcement day t . A matching sample is not strictly needed for the return

¹²Note that because the sample means and standard deviations are constants, this normalization does not affect the statistical significance of the estimated response coefficients.

¹³Under an alternative hypothesis that inattentive investors have formed an expectation of the LEI announcement but do not know its exact value, simply demeaning leads to an errors-in-variables problem which would imply that our reported regression coefficients are biased towards zero.

regressions as the null hypothesis $\beta = 0$ is well-defined, but we nonetheless report the regression results for non-announcement days to ensure that our results are not driven by intra-day patterns in returns. Table 1 presents the results.

The regression coefficients for the 5-minute intervals before the announcement (from 9:30-10:00) are on average positive, but not significant at the 5% level.¹⁴ The regression coefficients on non-announcement days are also insignificant and on average half as big as the case for the announcement days. At the announcement (interval 10:00-10:05), the announcement day regression coefficient is positive and significant at the 5% level, while the non-announcement day regression coefficient is about a quarter in magnitude and insignificant. Thus, the LEI announcement is moving aggregate stock prices in the direction of the change in the LEI index: A one standard deviation change in the LEI gives, on average, a 3.5bp return response on the S&P500 futures.

The intercept in regression (2) is significant and negative in the 10:00-10:05 interval on announcement days. Since normalized LEI changes have zero mean, the sample average return in this 5-minute interval is thus significantly negative on the announcement days in our sample. This is unexpected and not straightforward to explain. There are no notable outliers in the return series and the median return is close to the mean return. To check whether this fact affects the significance of the LEI change, we run regression (2) at the announcement *without* an intercept term (i.e. we are forcing the intercept to be zero) and find that the results are essentially unchanged: The regression coefficient is in this case 0.0351, the t -statistic is 2.19 and the R^2 is 4.9%.¹⁵ Therefore, the negative and significant intercept is not an important factor for the finding that the LEI announcement significantly affects contemporaneous S&P500 futures returns.

3.2.1 Return reversal

To assess whether the price impact around the LEI announcement is permanent or transitory, we regress post-announcement returns from a telescoping return window, starting with the 10:05 to 10:10 return, then the 10:05 to 10:15 return, etc., until the 10:05 to 10:30 return, on the LEI announcement. Table 2 displays the results.

The regression coefficients are negative and increasing in absolute value and, in terms of

¹⁴It is interesting, however, to note that the coefficient for the 9:35 - 9:40 interval regression on announcement days is positive and marginally significant (p -value of 0.06). It is in this interval The Conference Board releases its announcement to the news agencies that report the release at 10:00.

¹⁵The regression coefficient appears to be equal to the one obtained when including an intercept in the regression. However, it is not equal before round-off.

TABLE 1
Return Regressions

$$R_{i,t_0-t_1} = \alpha_i + \beta_i \Delta \overline{LEI}_t + \varepsilon_{i,t}$$

<i>Time</i>	<i>Announcement Days</i>				<i>Non-Announcement Days</i>			
$t_0 - t_1$	α (<i>s.e.</i>)	β (<i>s.e.</i>)	R^2	$p - val$	α (<i>s.e.</i>)	β (<i>s.e.</i>)	R^2	$p - val$
9:30 - 9:35	-.0047 (.0147)	.0180 (.0160)	2.09%	0.26	-.0176 (.0154)	.0021 (.0132)	0.03%	0.87
9:35 - 9:40	.0073 (.0146)	.0257* (.0133)	4.19%	0.06	-.0166 (.0182)	.0285 (.0194)	3.34%	0.15
9:40 - 9:45	.0115 (.0136)	-.0144 (.0132)	1.57%	0.28	-.0195 (.0189)	.0178 (.0181)	1.24%	0.33
9:45 - 9:50	.0148 (.0159)	.0084 (.0168)	0.39%	0.62	-.0137 (.0173)	-.0081 (.0188)	0.31%	0.67
9:50 - 9:55	.0125 (.0145)	-.0147 (.0152)	1.43%	0.34	.0086 (.0176)	-.0087 (.0199)	0.34%	0.66
9:55 - 10:00	.0272 (.0150)	.0038 (.0166)	0.09%	0.82	-.0033 (.0150)	.0125 (.0137)	0.97%	0.36
10:00 - 10:05	-.0437** (.0176)	.0351** (.0162)	5.33%	0.03	-.0232 (.0165)	.0072 (.0177)	0.26%	0.69
10:05 - 10:10	-.0162 (.0152)	-.0085 (.0153)	0.44%	0.58	.0264 (.0134)	.0019 (.0129)	0.03%	0.89
10:10 - 10:15	-.0185 (.0159)	-.0090 (.0184)	0.45%	0.63	.0001 (.0170)	.0040 (.0152)	0.08%	0.80
10:15 - 10:20	-.0213 (.0138)	-.0125 (.0117)	1.15%	0.29	-.0291** (.0140)	.0025 (.0150)	0.05%	0.87
10:20 - 10:25	-.0377 (.0146)	-.0020 (.0144)	0.03%	0.89	-.0225 (.0154)	-.0163 (.0160)	1.57%	0.31
10:25 - 10:30	-.0306** (.0136)	-.0001 (.0119)	0.00%	0.95	.0035 (.0161)	-.0044 (.0117)	0.11%	0.71

Table 1: This table reports estimates from OLS regressions of S&P500 futures return on the same-day normalized LEI announcement for announcement days, and matched LEI announcement for non-announcement days. There are 72 observations in each group. Returns are multiplied by 100, standard errors are corrected for heteroskedasticity (White standard errors). The changes in the LEI index have been normalized to have mean zero and unit variance. * denotes significant at the 10 percent level, while ** denotes significant at the 5 percent level in a two-tailed test.

TABLE 2
Return Reversal Regressions

$$R_{t,t_0-t_1} = \alpha_{t_0-t_1} + \beta_{t_0-t_1} \Delta \overline{LEI}_t + \varepsilon_{t,t_0-t_1}$$

Start time 10:05 to ...	End time for return calculation				
	10:10	10:15	10:20	10:25	10:30
β	-0.0085	-0.0175	-0.0300	-0.0032	-0.0033
(std. error)	(0.0153)	(0.0223)	(0.0233)	(0.0317)	(0.0324)
R^2	0.0%	0.9%	1.8%	1.5%	1.1%
p-val	0.58	0.43	0.20	0.31	0.34

Table 2: This table reports estimates from OLS regressions of the S&P500 futures returns of a telescoping return window on the same-day normalized LEI announcement for announcement days. There are 72 observations. Returns are multiplied by 100 and standard errors are corrected for heteroskedasticity (White standard errors). The changes in the LEI index have been normalized to have mean zero and unit variance. * denotes significant at the 10 percent level, while ** denotes significant at the 5 percent level in a two-tailed test.

magnitudes, there appears to be a reversal in the return data. However, none of the regression coefficients are statistically significant. Thus, the data unfortunately cannot reliably tell us whether the return response is transitory or permanent, but only provides suggestive evidence that the return response is transitory. Under this interpretation, the demand of inattentive investors exerts temporary price pressure which is partly reversed over the latter half of the event window. Under the permanent return response interpretation, the increased demand of inattentive investors has a lasting effect on prices as these investors update their expectations of economic conditions and thus their demand for risky assets.

3.2.2 Benchmarking Against Major Macro News Announcements

The return response documented in the previous section is small in magnitude. However, when benchmarked against major macro economic news announcements such as Non-Farm Payroll and New Home Sales, the response is comparable. Figure 2 shows the response of 5-minute returns to the LEI announcement next to the statistically significant 5-minute return

responses to macro economic news announcements taken from Andersen et al. (2007).¹⁶ These authors run the same regressions as in our equation (2), also using S&P500 futures returns, but with certain differences in the data period and construction. Their sample period is different from ours, 1994 to 2002 versus 1997 to 2006, but with a six-year overlap. Further, Andersen et al. (2007) define macro news announcements by subtracting conditional investor expectations, obtained from survey data, from the actual announcement and then normalize this news data so the standard deviation of each macro series is one. In our case, subtracting such measures of investor expectations is not appropriate. Under the null hypothesis, the expected value is equal to the announced value, so all “news” values would be zero. Instead, we simply demean and normalize the announcements as they are reported. The comparison of the regression coefficients is therefore fair in that all series have unit variance, but we note the caveats that the sample periods and the construction of the variables differ somewhat.

3.2.3 Trading Strategies

The results using the S&P500 futures returns are based on transaction prices. This raises two questions. First, is the return response due to a bid-ask bounce? In this case, a high LEI leads to buys at the ask, while a low LEI leads to sells at the bid, without the midpoint of the bid and the ask prices actually changing. Second, even if midpoint prices are moving in the direction of the LEI, which indicates failure of market efficiency in the Grossman and Stiglitz (1980) sense, is the market response to the LEI within the bid-ask spread and thus could not have been traded on?

Unfortunately, quotes data for the S&P500 futures for our sample period were is not publicly available. Therefore, we turn the analysis to the SPDR (Spider): an exchange-traded fund that tracks the S&P500 index (ticker symbol SPY). The price of the Spider is 1/10 of the index level and ranges from \$80 to \$153 in the sample period. Intraday trades and quotes on the Spider can be obtained from the NYSE Trades and Quotes (TAQ) database. This data allows us to run return regressions based on index prices determined as the midpoint of the bid-ask spread, as well as evaluate trading strategies taking into account

¹⁶Andersen et al. (2007) investigate all macro releases *including* the LEI, but do not find significant evidence that it has a price impact. We offer two explanations for the discrepancy between our results. First, in their Table 4, they state that the LEI is released at 8:30am. This is true only for the beginning of their sample. In our sample, from 1997 and onwards, the release time is always at 10:00am. At present we do not know if the authors corrected the change in release time over the sample, but they give no indication in their paper that they do. Second, and more fundamentally, they investigate normalized “surprises” based on market estimates obtain from a survey database (MMS). As we discuss above, it is unclear what these “shocks” represent since the index is perfectly forecastable.

FIGURE 2
LEI Return Response: Benchmark Against Major U.S. Macro Releases

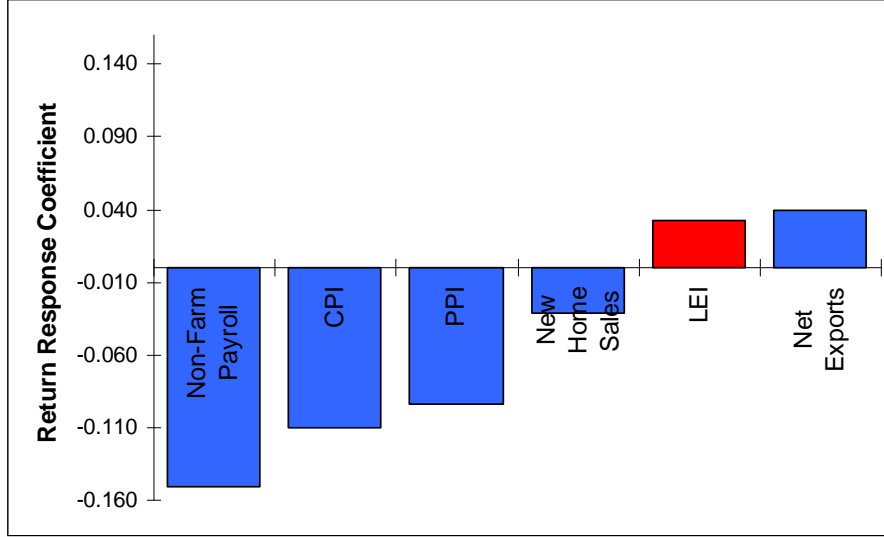


Figure 2: This figure shows the significant five-minute S&P500 futures return response to macroeconomic news announcements from Andersen et al. (2007) next to the five-minute return response to the normalized LEI announcement from Table 1.

bid-ask spreads. We use standard filters to clean the TAQ data.¹⁷ The trading strategies are only suggestive as we cannot know if the prescribed trades would have moved the subsequent bid and ask prices had they been executed. We also ignore any fees, such as brokerage fees, incurred when trading.

Table 3 shows the regression of midpoint returns on the Spider on the normalized LEI announcement. As for the S&P500 futures return, the 10:00 - 10:05 return regression gives a positive and statistically significant (at the 5% level) regression coefficient. Again the intercept is statistically significant and negative. However, the results are in fact stronger if we force the intercept to be zero.¹⁸ For no other 5-minute interval is the coefficient significant. Thus, the results using prices based on the midpoint confirm the finding in Table 1 for the S&P500 futures return, and we conclude that the regression results are not due to a bid-ask bounce

¹⁷We apply the following filters to clean the trade and quote data (Hendershott and Moulton (2007)). We use only trades for which TAQ's CORR field is equal to zero, one, or two and for which the COND field is either blank or equal to @, E, F, I, J, or K. We eliminate trades with nonpositive prices or quantities. We eliminate trades with prices more than (less than) 150% (50%) of the previous trade price. We use only quotes for which TAQ's MODE field is equal to 1, 2, 6, 10, 12, 21, 22, 23, 24, 25, or 26. We eliminate quotes with nonpositive price or size or with bid price greater than ask price. We exclude quotes when the quoted spread is greater than 25% of the quote midpoint or when the ask price is more than 150% of the bid price.

¹⁸We also regress the 10:00 - 10:05 return on the normalized LEI change *without* an intercept term. The regression coefficient in this case increases to 0.033, with a *t*-statistic of 2.04.

TABLE 3
Spider Midpoint Return Regressions

$$R_{i,t_0-t_1}^{SPY} = \alpha_i + \beta_i \Delta \overline{LEI}_t + \varepsilon_{i,t}$$

<i>Time</i> $t_0 - t_1$	α (<i>s.e.</i>)	β (<i>s.e.</i>)	R^2	<i>p-value</i>
9 : 30 – 9 : 35	−.069 (.042)	−.039 (.045)	1.5%	0.40
9 : 35 – 9 : 40	−.003 (0.015)	.020 (0.013)	2.9%	0.12
9 : 40 – 9 : 45	0.016 (0.017)	0.002 (0.012)	0.0%	0.87
9 : 45 – 9 : 50	0.026 (0.019)	0.005 (0.019)	0.1%	0.80
9 : 50 – 9 : 55	0.001 (0.015)	−0.013 (0.013)	1.3%	0.33
9 : 55 – 10 : 00	0.049** (0.020)	0.011 (0.019)	0.6%	0.56
10 : 00 – 10 : 05	−0.052** (0.020)	0.032** (0.016)	4.7%	0.05
10 : 05 – 10 : 10	0.020 (0.027)	0.012 (0.027)	0.3%	0.66
10 : 10 – 10 : 15	−0.014 (0.029)	−0.017 (0.032)	0.6%	0.59
10 : 15 – 10 : 20	−0.089 (0.037)	−0.011 (0.036)	0.2%	0.75
10 : 20 – 10 : 25	−0.040 (0.038)	−0.033 (0.039)	1.4%	0.40
10 : 25 – 10 : 30	−0.116** (0.045)	−0.028 (0.047)	0.6%	0.56

Table 3: This table reports estimates from OLS regressions of the Spider five-minute returns on the same-day normalized LEI announcement for announcement days. The number of observations vary between 63 and 69, as there are a few instances early in the sample where the Spider does not trade in the relevant five-minute interval. Returns are multiplied by 100 and standard errors are corrected for heteroskedasticity (White standard errors). The change in the LEI has been normalized to have mean zero and unit variance. * denotes significant at the 10 percent level, while ** denotes significant at the 5% level in a two-tailed test.

but are instead the consequence of fundamental price changes.

We now ask whether trading strategies based on the LEI release can be profitable after accounting for transaction costs as implied by the bid-ask spread. Panel A of Table 4 shows the average nominal bid-ask spread for the Spider in the first hour of market open as well as for the interval 9:55 - 10:05 for each year in the sample. The average nominal bid-ask spread decreases strongly between 2001 and 2003, while volume increases. In the first part of the sample, the average bid-ask spread is roughly 20 basis points of the price, whereas in the last half of the sample the average bid-ask spread is about 3 basis points of the price. The bid-ask spread will naturally affect the profitability of a trading strategy, and we therefore focus on both the full sample, 1997 – 2005, and the second half, 2002 – 2005.

We first consider a return-based measure of the profitability of trading on the LEI release. To ensure robustness of the results, we consider a range of trading strategies constructed as follows. We start trading at a given time before 10:00 and trade an equal dollar amount every minute up until, but not including, 10:00. We then hold this portfolio until 10:05, when we unload the entire position. The trade is in the direction of the LEI change: If the release is above average, we start buying the Spider before the announcement and sell at 10:05, and vice versa. Buys are made at the then available ask, while sells are made at the bid. To avoid using future information, we let the average of the LEI change, which determines the threshold between buys and sells, be equal to its long-run historical median using data up until 1997 (which is 0.1). Note that this cut-off point leads to an equal number of long versus short days. This is important as the intercept effects discussed earlier are in this case not a concern.

Panel B of Table 4 shows the average returns from this strategy. As is apparent, the average announcement day return for the full sample is negative and about -5 basis points. However, for the latter part of the sample, the returns become positive: about 5 basis points if trading commences between 9:30 and 9:45, and decreasing afterwards. The change in trading strategy returns between the two samples is due to the change in bid-ask spreads, which are much higher in the first half of the sample. Given that the return response is fairly low, high bid-ask spreads lead to negative returns. Further, the bid-ask spread closer to 10:00 is slightly higher than the average for the hour, which partly explain the lower returns for the trading strategies that start at 9:50 and 9:55.

Panel C of Table 4 shows the average announcement-day *dollar* profits from a volume-weighted trading strategy using the available bid and ask prices. Instead of trading an equal amount in the interval from the given start time until, but not including, 10:00, we

TABLE 4
Spider Trading Strategies

Panel A: Bid-Ask Spreads and 5-Minute Average Volume				
Year	9:30 - 10:30		9:55 - 10:05	
	Bid-Ask	Volume	Bid-Ask	Volume
1997	0.182	63,431	0.194	58,343
1998	0.170	106,110	0.155	117,783
1999	0.324	88,704	0.525	114,214
2000	0.213	120,999	0.200	150,325
2001	0.216	278,935	0.155	262,114
2002	0.100	468,839	0.135	498,917
2003	0.048	549,987	0.048	629,008
2004	0.042	327,091	0.044	272,965
2005	0.028	541,598	0.037	490,544

Panel B: Trading Strategy: Returns Net of Bid-Ask Spread		
Start time	1997 - 2005	2002 - 2005
	Average Return	Average Return
9:30	-0.0605%	0.0504%
9:35	-0.0490%	0.0521%
9:40	-0.0507%	0.0478%
9:45	-0.0514%	0.0402%
9:50	-0.0511%	0.0288%
9:55	-0.0544%	0.0219%

Panel C: Trading Strategy: \$ Profit Net of Bid-Ask Spread		
Start time	1997 - 2005	2002 - 2005
	Average Profit	Average Profit
9:30	\$44,062	\$157,071
9:35	\$35,419	\$115,988
9:40	\$31,334	\$89,076
9:45	\$15,399	\$54,569
9:50	\$3,595	\$21,167
9:55	\$ - 2,037	\$3,853

Table 4: Panel A reports the average nominal bid-ask spread and average 5-minute volume for each year in the sample for the given time period. The price of the Spider ranged between \$80 and \$153 in this period so, to give an example, the average bid-ask spread in 2005 was about 2.5 basis points. Panel B shows the average return to the trading strategy based on bid and ask prices, while Panel C shows the average profits of the volume-weighted trading strategy. The trading strategies are conducted both over the full sample and over the sub-period 2002-2005 (after 2001 there was a large drop in the bid-ask spreads which increases the profitability of the trading strategies).

now trade a number of Spider shares equal to half the volume in a given minute, which we assume is the number of buys or sells in each minute. At 10:05, we begin unloading the shares - again according to half the volume in each minute thereafter, until we hold no more shares. If we still have shares left at 10:29, the remainder of the position is assumed to be liquidated at 10:29 prices. While this trading strategy gives the maximal amount of trading that would have been possible, it is easy to scale: If trading only $1/5$ of half of the volume seems more reasonable, one can simply divide the dollar profits we report by five. Panel C shows that for the full sample, the average announcement day trading profit is \$44,062 if trading starts at market open. If instead trading starts at 9:55am, the strategy leads to an average daily loss of \$2,037. While the latter loss seems consistent with the reported negative return from the full sample reported in Panel B, the gain if one starts trading at the open does not. However, higher volume is accompanied by lower bid-ask spread in the data. Thus, the volume-weighted trading strategy in effect takes advantage of periods with lower bid-ask spreads - both within the hour and, more importantly for these results, across time. The results for the 2002-2005 period confirms this. Here volume is higher, bid-ask spreads are lower and the dollar profits are consistently positive, ranging from \$157,071 per announcement day if trading commences at market open, to \$3,853 if trading starts at 9:55.

Thus, using historical data on available bid and ask prices for the Spider ETF, we show that the market response to the LEI release gives rise to profitable hypothetical trading strategies, especially in the latter half of the sample when the bid-ask spreads were markedly lower. However, we do not claim that these trades were in fact feasible as that would require estimating the market impact of additional trades. At the same time, this analysis excludes parallel trades that an arbitrageur may have also been able to execute profitably in other instruments, such as the S&P500 futures. Further, we assume that the hypothetical trader does not consider the size of the bid-ask spread when implementing the trades. A complete evaluation would therefore have to take into account all assets that respond to the announcement as well as estimates of their trading costs. We conclude that while it may be that the profit opportunities documented here, if acted upon, would have been close to no-arbitrage bounds, the results in Table 4 suggest that the magnitude of the market response to the LEI release is economically significant.

3.3 Volatility

In this Section, we test whether five-minute stock return volatility is higher on announcement days compared to non-announcement days in each of the five-minute intervals in the hour around the announcement.

It is well-documented that aggregate stock return volatility is time-varying. To control for this, we employ a matching study. First, we calculate the volatility of five-minute returns for each *non*-announcement day for the relevant trading hour. Next, we divide the five-minute returns on both the corresponding announcement day and the non-announcement day by this volatility measure.¹⁹ We use only the *non*-announcement days' volatility in order to capture any overall higher levels of volatility on announcement days in the subsequent volatility tests. This normalization is valid under the null hypothesis that the volatility over matched announcement and non-announcement days are equal.

Next, we calculate the volatility of five-minute (normalized) announcement and non-announcement day returns for each interval as follows. Let $\tilde{R}_{i,t}$ be the *normalized* five-minute log return for the interval i , where $i \in \{9:30-9:35, 9:35-9:40, \dots, 10:25-10:30\}$. Interval i 's variance estimate is then

$$\hat{\sigma}_i^2 = \frac{1}{T} \sum_{t=1}^T \tilde{R}_{i,t}^2 \quad (4)$$

where the subscript t corresponds to the announcement or non-announcement days in our sample, which are indexed 1 to 72. To test whether the variance on announcement days is different than on non-announcement days, we apply a Levene F-test for each interval i .²⁰

Column 2 in Table 5 shows the results. The ratios of announcement vs. non-announcement days' volatility exhibit a significant spike for the interval 10:00-10:05, which corresponds to the time the LEI index is announced. The increase is not only statistically significant (at the 5% level), but also economically sizable – volatility increases by an average of 25%. Before 10:00, there appears to be no overall pattern in the volatility ratio: volatility is about the same on announcement vs. non-announcement days. There is one statistically significant

¹⁹We calculate standard deviations assuming the expected five-minute returns are equal to zero. This is a standard assumption given the short time-interval and yields more robust volatility estimates. Using the residuals of a regression of intraday returns on their lagged value (to capture any bid-ask bounce, which we do not find significant) does not produce qualitatively different results.

²⁰It is common in empirical work to use modified Levene F-tests (for example the Brown-Forsythe modified Levene-test), as these are generally more robust to departures from normality of returns. We assume the expected five-minute return is equal to zero, which is neither the sample mean, median nor the 10% trimmed mean, but which empirically turns out to be very close to the median.

TABLE 5
Return Volatility and Volume Ratios

$t_0 - t_1$	<i>Volatility Ratio</i> (<i>p - value</i>)	<i>Volume Ratio</i> (<i>p - value</i>)
9 : 30 – 9 : 35	1.186 (0.23)	0.978 (0.46)
9 : 35 – 9 : 40	0.785** (0.02)	1.016 (0.64)
9 : 40 – 9 : 45	0.934 (0.72)	1.049 (0.14)
9 : 45 – 9 : 50	1.146 (0.41)	1.031 (0.31)
9 : 50 – 9 : 55	0.963 (0.90)	1.048 (0.10)*
9 : 55 – 10 : 00	1.179 (0.27)	1.046 (0.19)
10 : 00 – 10 : 05	1.252** (0.05)	1.068** (0.04)
10 : 05 – 10 : 10	1.133 (0.46)	1.067** (0.03)
10 : 10 – 10 : 15	1.037 (0.93)	1.070** (0.03)
10 : 15 – 10 : 20	1.326** (0.01)	1.071** (0.04)
10 : 20 – 10 : 25	1.017 (0.98)	1.071** (0.02)
10 : 25 – 10 : 30	1.240 (0.10)	1.099** (0.00)

Table 5: This table reports estimates of standard deviation of normalized 5-minute returns and 5-minute volume on announcement and non-announcement days. There are 72 observations in each group. The variance ratio test is a Levene F-test, where zero is assumed to be the median/mean return. The volume ratio is regressed on a constant. The null hypothesis is $\alpha = 1$. Standard errors are corrected for heteroskedasticity (White standard errors). * denotes significance at the 10 percent level, while ** denotes significance at the 5 percent level in a two-tailed test.

observation at 9:35-9:40 for which announcement days seem to have *lower* volatility than non-announcement days. After 10:00, the volatility ratios are all above 1, indicating that volatility is overall higher on announcement days in the half hour following the LEI release.

3.4 Volume

In this Section, we test whether volume is higher on announcement days compared to non-announcement days in each of the five-minute intervals in the hour around the announcement. To control for the strong increase in aggregate volume over the sample period and the well known intraday patterns in volume, we create normalized five-minute volume for each announcement day, $v_{i,t}$, by dividing the volume of the same five-minute interval on the matched non-announcement day:

$$v_{i,t} = \frac{\text{volume 5 min interval } i \text{ on announcement day } t}{\text{volume 5 min interval } i \text{ on non-announcement day } t'}. \quad (5)$$

We then regress this normalized volume on a constant for each 5-minute interval from market open at 9:30 until 10:30:

$$v_{i,t} = \alpha_i + \varepsilon_{i,t} \quad \text{where } i \in \{9:30-9:35, 9:35-9:40, \dots, 10:25-10:30\} \quad (6)$$

The null hypothesis we are testing is $\alpha = 1$. Column 3 of Table 5 reports the results. At market open the volume on non-announcement days is slightly higher than on non-announcement days, but the difference is insignificant. However, as we get closer to the 10:00 announcement, the volume ratio becomes larger than unity. It is larger than unity and statistically significant following the announcement, as it was for both returns and volatility. The volume effect, however, persists significantly throughout the half hour following the announcement.

3.5 Robustness

To examine the robustness of the results, we repeat the same analysis on the full set of announcement days. Recall that we initially excluded days on which other macro announcements were released. The full sample consists of 102 announcement days in the sample period January 1997 to August 2005. If the full sample is affected by the presence of other macro announcements, we would expect to find a weaker return response but a stronger volatility

and volume responses to the LEI announcements.

We find that the LEI announcement has very similar impact on aggregate stock market returns, volatility and volume, compared with the filtered sample. Specifically, we find that the return response at the time of the announcement (10:00 - 10:05) is positively related to the change in the LEI, although the coefficient is slightly smaller (0.028) and its statistical significance is weaker (t-statistic of 1.74). This is to be expected as the other announcements are imperfectly correlated with changes in the LEI index and therefore add noise.

In contrast to the return tests which depend on the sign of the announcement, volatility and volume are affected by the presence of other announcements. Indeed, we find that volatility increases by 28% following the announcement, which is stronger than for the filtered sample (25%) where the LEI is the only announcement that occurs. The same applies to trading volume. It increases by 8.8% following the announcement for the full sample, relative to 6.8% in the filtered sample.

3.6 Discussion of Aggregate Results

In sum, we show that the LEI announcements have a significant impact on aggregate proxies of information arrival such as returns, return volatility, and trading volume. The effect is short-lived for returns and volatility, consistent with previous studies of the impact of news announcements on aggregate prices. Volume, however, exhibits a more prolonged reaction. These findings are consistent with the presence of investors with limited attention, who find it optimal to focus on summary statistics as opposed to the individual components of the index.

The absolute level of the return response is fairly low. However, this result is expected given that limited attention should affect markets less if the information is market-wide, as is the case here. Investors have a higher incentive to be attentive to information that is more important for their utility and, as a group, investors therefore focus more on market-wide information. Further, since the release is recurring and replicable, one may expect attentive arbitrageurs to eliminate profit opportunities arising from the release up to transaction costs. Therefore, it is surprising that the LEI announcement has any significant market impact which, at least for the latter half of the sample, exceeds our measures of transaction costs of trading.

4 Cross-Sectional Test

In the previous section, we showed that the release of the LEI has a statistically significant impact on aggregate returns, volatility, and volume. To examine the robustness of the results we test another hypothesis. If the market impact of the LEI announcements are caused by limited attention of a subset of investors, we would expect to find a larger impact on stocks which investors subject to this bias are likely to trade. We test this conjecture by looking at the cross-sectional return response to the LEI release. Inattention-prone investors are more likely to trade large capitalization stocks, which have high volume and are featured more in the news (Barber and Odean (2006)), and stocks which have low book-to-market ratios (Lakonishok, Shleifer, and Vishny (1994)). Thus, limited attention suggests that large capitalization and low book-to-market stocks should respond more strongly to the release of the LEI. We construct intraday returns for the 25 Fama-French portfolios on the announcement days and show that, consistent with the limited attention effect, the returns of large capitalization and, to a lesser extent, low book-to-market stocks respond more to the LEI announcements, compared to small and high book-to-market stocks.

4.1 Portfolio Construction

Following the procedure described in Davis, Fama, and French (2000), we obtain the CUSIP numbers of the stocks in each of the 25 portfolios for every month from 1997 to 2005.²¹ We then extract from the TAQ database the transactions of every stock in each portfolio from 9:30 until 10:30 on the LEI announcement days, and construct 1-minute interval returns.

Calculation of portfolio returns using tick-by-tick data poses a challenge since many stocks do not trade frequently. To control for the effect stale prices may have, we use the following algorithm. For the time interval (for example 10:00 - 10:01), a stock's return is calculated if it traded during that minute and during the preceding minute (9:59 - 10:00). If a stock trades multiple times during both minutes, we use the latest trades in both minutes in order to calculate the return. The stocks that do not trade during either or both minutes are disregarded. The portfolio return is the equally-weighted return of all the stocks' returns that did trade between these two minutes. In Section 4.3, we discuss further the properties of this selection criteria.

²¹The only difference between their procedure and ours is due to the fact that we do not have the hand-collected data from *Moody's Industrial Manuals* that were used in Davis, Fama, and French (2000). We do not believe that this creates any systematic bias in our analysis.

Some summary statistics for all 25 portfolios are shown in Table 7 in the Appendix. It is worth pointing out that the average numbers of stocks in our portfolios are consistent with the data provided by Ken French on the daily 5×5 portfolios. Also, note that none of the portfolios have very few stocks trading during the minute when the LEI announcements are made: the minimum is 20 stocks and that is in the large size portfolios, where there is ample liquidity and each stock trades frequently. In the small size portfolios, which might be most subject to liquidity and stale price problems, there are always enough stocks trading between 10:00 and 10:01, the minimum being 54. Lastly, we highlight the fact that the average 1-minute returns during the event window (9:30 - 10:30) are not statistically different from zero across all portfolios, which gives us confidence that these high-frequency returns are not biased in any particular way.

4.2 Tests and Results

The limited attention hypothesis suggests that large and low book-to-market stocks should have a higher announcement effect compared to small and high book-to-market stocks. In order to test this hypothesis, we use intraday returns on 5×5 size and book-to-market sorted portfolio described above and we regress the return of each portfolio from 10:00 to 10:01 on the normalized change in the LEI:

$$R_{i,10:00-10:01} = \alpha_i + \beta_i \cdot \Delta \overline{LEI}_t + \varepsilon_{i,t} \quad \text{for all 72 dates in our sample} \quad (7)$$

where $R_{i,10:00-10:01}$ is the return of portfolio i from 10:00 to 10:01.

Panel A of Table 6 shows the results from the above regressions. Three main patterns emerge from this analysis. First, the regression coefficients are positive for almost all portfolios, consistent with the aggregate results presented in the previous section. Second, for each book-to-market quintile, the regression coefficient β_i tends to be bigger for larger size portfolios, which suggests that there is a bigger announcement effect for large stocks. For instance, for the medium book-to-market category (column 3), the coefficient goes from being negative and insignificant for the smallest size portfolio to being positive and significant for largest size portfolio.

To investigate whether this size effect is statistically significant, we first construct aggregate size quintile portfolios (one-way sort on size). Second, we regress the announcement returns of a portfolio that is long the largest size quintile and short the smallest size quintile on the LEI announcement. The resulting regression statistics are shown in Panel B of Table

TABLE 6
Cross-Sectional Return Regressions

Panel A:		$R_{i,10:00-10:01} = \alpha_i + \beta_i \cdot LEI_t + \varepsilon_{i,t}$				
		Book-to-Market				
		L	2	3	4	H
Size	S	-0.0147 (0.0127)	0.0084 (0.0123)	-0.0031 (0.0137)	0.0237** (0.0111)	-0.0171 (0.0187)
	2	0.0128 (0.0105)	-0.0027 (0.0101)	0.0070 (0.0072)	0.0096** (0.0057)	0.0101 (0.0081)
	3	0.0209** (0.0087)	0.0094 (0.0062)	0.0040 (0.0054)	0.0032 (0.0055)	0.0056 (0.0070)
	4	0.0188** (0.0103)	0.0148** (0.0072)	0.0144** (0.0062)	0.0156** (0.0059)	0.0137 (0.0117)
	B	0.0305** (0.0113)	0.0256** (0.0082)	0.0243** (0.0087)	0.0222** (0.0072)	0.0184** (0.0089)
Panel B:		$R_i - R_j = \alpha_{ij} + \beta_{ij} \cdot LEI_t + \varepsilon_{ij,t}$				
Specification	Category	R_i	R_j	α_{ij}	β_{ij}	R^2_{adj}
1	Size	Big	Small	0.0013 (0.0085)	0.0248** (0.0092)	10.7%
2	Book-to-Market	Low	High	-0.0032 (0.0072)	0.0075 (0.0081)	1.5%

Table 6: Panel A of the table reports β_i coefficient estimates from OLS regressions of return data for each of the 25 Fama-French portfolios from 10:00 to 10:01 on the same-minute LEI announcement. There are 72 observations in each group. Returns are multiplied by 100 and standard errors are corrected for heteroskedasticity (White standard errors). The change in LEI is normalized to have mean zero and unit variance. ** denote statistical significance at the 5% level in a two-tailed test. Panel B shows the differences in portfolio returns for four “corner” portfolios created by one-way sorts along the size and book-to-market directions.

6, specification 1. The regression coefficient is positive and significant at the 5% level with an R^2 of 10.7%. Thus, large capitalization stocks react more strongly to the release of the LEI than small capitalization stocks.

The third pattern that emerges from Panel A of Table 6 is that, as book-to-market increases, the regression coefficient β_i tends to decrease, i.e. the LEI announcement effect is smaller. To assess whether this book-to-market pattern is statistically significant, we do the same test across book-to-market quintile portfolios as we did across the size portfolios. In particular, we construct aggregate book-to-market sorted quintile portfolios and test whether a portfolio that is long the lowest book-to-market quintile and short the highest book-to-market quintile has a significant return response to the announcement. Specification 2 of Panel B in Table 6 reports the corresponding regression statistics. The regression coefficient is positive, as expected, but not statistically significant.²² Thus, we do not find significant evidence of an unconditional book-to-market effect.

In sum, we find strong evidence that large capitalization stocks respond more strongly to the LEI announcement compared to small capitalization stocks, but only suggestive evidence on the relationship between book-to-market and the announcement response.

4.3 Liquidity, Bid-Ask Spreads, and the Bid-Ask Bounce

Could the cross-sectional results be explained by differences in liquidity across the portfolios? After all, spreads and bid-ask bounce are higher for small market capitalization stocks. We argue that this would lead us to over-reject the null. To see that, consider a day with a positive LEI announcement. Since prices respond to the announcement, we are likely to observe an increase in orders executed at the ask price. For small stocks, which have large bid-ask spread, the bid-ask bounce would generate “extra” returns compared to large stocks that have smaller bid-ask spreads. As a result, effects related to bid-ask spreads and bounce go *against* our results.

Another possible explanation for the lower observed announcement response for small stocks is that they are more illiquid compared to large stocks. However, in the construction of the 1-minute returns to the 25 Fama-French portfolios, we only take into account the stocks that trade in both the 9:59 - 10:00 minute and the 10:00 - 10:01 minute. As a result, stale prices do not lead to any systematic biases in the constructed portfolio returns. Table

²²In regressions (not reported in the paper) we find that the regression coefficient on high minus low book-to-market portfolios are consistently positive but not statistically significant for all size quintiles.

7 in the Appendix shows that there are many stocks trading in each portfolio at the time of the announcement, supporting the idea that the portfolios are well-diversified. Table 8 in the Appendix provides further evidence that this procedure does not lead us to disregard stocks in a way that would systematically bias our portfolio returns. We report the percentage of minutes in the 9:30 - 10:30 hour during which a stock traded, conditional on the fact that it *did* (first panel) or *did not* (second panel) trade during the announcement minute. The differences are large across all portfolios and suggest that the stocks we disregard are more illiquid stocks in general, and not just during our interval of concern (10:00 - 10:01).

5 Conclusion

In this paper we present evidence that investors act on summary information, impacting aggregate stock market returns, volatility and volume. The paper uses a weak restriction on aggregate prices to test for the presence of limited investor attention: Markets should not respond to the release of summary statistics that are based on information already available. We identify a unique stream of releases, the U.S. Leading Economic Index (LEI), that is released on an ongoing basis at pre-determined times, consists of previously published macro data, is calculated using a publicly available methodology, and is widely followed by the mass media. We show that this series has statistically significant effects on proxies for information arrival such as instantaneous market-level returns (which move in the direction of the announcement), return volatility, and trading volume.

Since the test pertains to aggregate information, the effects of limited attention on returns should be constrained by information gathering incentives and arbitrageurs. Peng and Xiong (2006) show that investors with a limited attention choose to expend a larger fraction of their resources on aggregate information, such as the index constituents of the LEI. Further, since the LEI is released every month at a pre-determined time and date, it is relatively easy for arbitrageurs to profit from a market return reaction to its release. Therefore, if investors suffer from limited attention, the market return impact should still be small, which is what we find. However, the other proxies for the arrival of information, volatility of volume, increase substantially following the announcement. Thus, the evidence provided in this paper indicates that summary statistics like the LEI are valuable to a significant fraction of investors, even though the information provided is technically stale. More broadly, this suggests a role for other summaries of information such as the ones provided by the financial press.

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6 Appendix

6.1 LEI Calculation

Let $\Delta LEI_{t,t-1}$ denote the monthly change in the LEI for month $t - 1$ published in month t . This monthly change is calculated as the sum of component contributions which are derived from a symmetric percentage change formula:

$$\Delta LEI_{t,t-1} = \left(\sum_{i=1}^{10} \sigma_i * 200 * \frac{X_{i,t} - X_{i,t-1}}{X_{i,t} + X_{i,t-1}} \right) \quad (8)$$

where σ_i is the standardization factor calculated by dividing the inverse standard deviation of component i by the sum of the inverse standard deviations over all components. As the notation makes clear, the index published in month t refers to past data for $t - 1$ which has already been published.

Since January 2001, leading indicator components for month $t - 1$ that are not available at the time of publication, month t , are estimated by TCB using a univariate autoregressive model to forecast each unavailable component. This procedure seeks to address the problem of varying availability in its components (publication lags). Without it, the index would contain incomplete components or it would not be available promptly under the current schedule.

In the publication schedule prior to January 2001, the index published in month t referred to the month $t - 2$. In the new schedule after January 2001, the index published in month t refers to the preceding month $t - 1$ (this information is available from The Conference Board). For example, in the old publication schedule the index would be calculated in the first week of March (t) for January ($t - 2$), and the January value of the LEI would use a complete set of components. According the new schedule, the index is calculated in the third week of March for February ($t - 1$), and the February value of the index uses 70% of the components which are already available and remaining 30% are forecast. As seen in this example, users of the LEI would have had to wait for two more weeks until April for the February index.

The missing components (Manufacturers' New Orders for Consumer Goods and Materials, Manufacturers' New Orders for Nondefense Capital Goods, and the personal consumption expenditure used to deflate the Money Supply (M2)) are estimated using a time series regression that uses two lags (see McGuckin, Ozyildirim, and Zarnowitz (2001) for more on

this model and a comparison with other alternative lag structures). The procedure used to estimate the current month's Personal Consumption Expenditure Deflator (used in the calculation of Real Money Supply and Commercial and Industrial Loans Outstanding) incorporates the current month's Consumer Price Index when it is available before the release of the LEI. When the unavailable data become available in the next month, the index is revised.

The missing components could be forecast through alternative means. However, The Conference Board has focused on simplicity, stability, and low costs of production and argues for concentrating on easily implemented autoregressive model. Note that under the pre-2001 release schedule of the LEI, it would have been possible to perfectly forecast the new value each month just by collecting the individual data components and following the index calculation methodology. In the post-2001 schedule, this is still possible, but the estimated components require one additional step.

TABLE 7
Descriptive Statistics of the Intraday Fama-French Portfolios

Portfolio #	\bar{r}_{1-min} (%)	σ_{1-min} (%)	$\bar{N}_{portfolio}$	$\bar{N}_{t,LEI}$
1	-0.00617	0.19262	580	93
2	-0.00409	0.24114	433	59
3	-0.00354	0.20421	505	54
4	-0.00408	0.22387	675	55
5	0.00337	0.20218	960	69
6	-0.00372	0.10093	201	82
7	-0.000737	0.10228	156	62
8	0.00282	0.13706	158	54
9	0.0037	0.15862	149	49
10	0.01208	0.61251	91	30
11	-0.00028	0.10274	163	91
12	-0.00174	0.07271	119	62
13	0.000509	0.07263	105	53
14	0.00196	0.08177	82	41
15	0.0015	0.09624	47	24
16	-0.00227	0.07047	138	102
17	0.00108	0.1789	100	68
18	0.00244	0.12944	78	50
19	0.000728	0.05695	54	35
20	0.000566	0.08681	36	19
21	-0.000876	0.07975	158	144
22	0.00164	0.1503	78	63
23	-0.000564	0.0771	50	37
24	0.000232	0.05572	36	28
25	-0.000134	0.06687	28	20

Table 7: For each of the 25 Fama-French portfolios, we report the average 1-minute returns \bar{r} over the hour from 9:30 to 10:30 along with the respective standard deviations of returns σ . We also report the average number of stocks in each portfolio $\bar{N}_{portfolio}$ and the average number of stocks $\bar{N}_{t,LEI}$ trading from 10:00 to 10:01 in each portfolio. All these summary statistics are for our entire dataset of 72 dates spanning from February 1997 to August 2005. Note that the idiosyncratic nature of the returns and standard deviations of portfolio 10 seems to be due to an error in the TAQ data. We can confirm that this potential error does not occur between 10:00 and 10:01.

TABLE 8
Liquidity of Stocks during the Announcement Hour

Stocks with trade at 10:00-10:01						
Book-to-Market						
	L	2	3	4	H	
Size	S	45.78	41.34	36.36	34.85	34.96
	2	61.50	55.32	51.23	47.71	49.80
	3	70.66	63.23	61.41	60.28	61.15
	4	80.19	73.99	71.60	72.45	73.18
	B	91.68	86.95	86.41	84.60	82.98

Stocks without trade at 10:00-10:01						
Book-to-Market						
	L	2	3	4	H	
Size	S	15.83	13.19	11.37	9.89	9.35
	2	33.57	27.79	25.59	26.41	26.29
	3	45.20	37.22	36.94	36.16	39.40
	4	54.30	45.30	45.86	46.24	35.38
	B	56.32	53.18	48.16	45.45	41.09

Table 8: This table shows the percentage of minutes in the 9:30 - 10:30 hour during which a stock did trade. The first panel shows this percentage conditional on the stock having traded during the 10:00 - 10:01 minute. The second panel shows this percentage conditional on the stock not having traded during the 10:00 - 10:01 minute. The percentages presented are averaged across all stocks and all 72 announcement dates within each portfolio.